

MEMO No            CFD/TERMO-18-97

DATE: August 7th, 1997

TITLE

ZGRID User Guide

AUTHOR(S)

Juhaveikko Ala-Juusela

ABSTRACT

User guide for ZGRID. ZGRID is a grid generation program for two-dimensional single jets. Includes general instructions and an example of use.

MAIN RESULT

PAGES

3

KEY WORDS

FINFLO, jet, grid generation

APPROVED BY

Timo Siikonen

August 7th, 1997

# 1 What is ZGRID

ZGRID is a grid generator for numerical modeling of two-dimensional single jet. In other words it creates calculation grid i.e. corner points of control volumes, so that it can be used with FINFLO or any other CFD-program.

The main goal for the program has been a programming lesson for the author but also to make fast and easy to use tool for beginners in the field of flow modeling.

## 2 How to use it

### 2.1 General instructions

Copy the program into your working directory. The executable program is in file **zgrid** and the fortran source code in file **zgrid.f**. Then just type **zgrid** to prompt and the program starts.

There are two modes in the program. The first mode needs to know only the width of a nozzle and the number of control volumes in the nozzle. The second mode allows the user to define more specifically what kind of grid is wanted. Additional information that is given in the second mode is: number of the cells in the  $x$ - and  $y$ -directions as well as in the nozzle, and the size of the grid. But try to give dimensions and numbers that make sense.

Later it might be useful to write a textfile that consist all the input data the program is asking and then pipe it to the program. That way you got the input data saved and it is easy to change one or two numbers and to keep the rest of the data as the same.

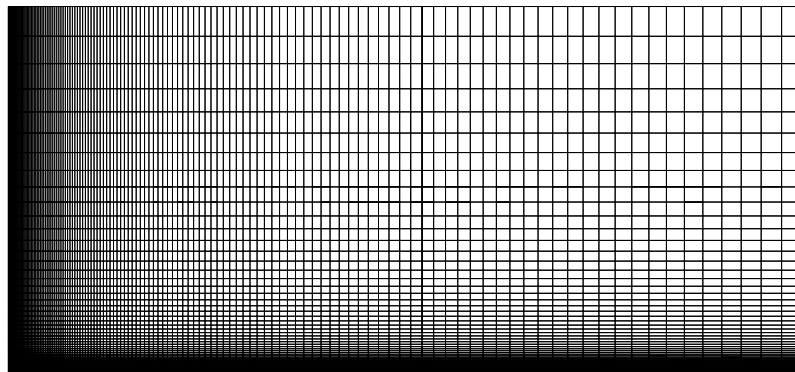
*Example: DIONYSOS> zgrid < data*

where **data** is a textfile containing input data.

The program makes three files in the working directory: **xvalues**, **yvalues** and **XYZ.BIN**. In **xvalues** and **yvalues** files there are  $x$ - and  $y$ -distributions, respectively. These files are in AS-CII format so its possible to see the distributions the program has made with any editor or using a cat command. XYZ.BIN contains corner points of the control volumes in binary format and it is possible to take a look of the grid for example using **finplo** program or any other visualization program utilize Plot3D-format. The file itself is in a format that FINFLO understands it, but the name should be changed to something else because FINFLO produces also a file named XYZ.BIN.

### 2.2 Example

An example of the grid plotted with **finplo** is in Figure 1 and it is the result of example run below. The nozzle is on the left side of the grid and the centerline of the stream is at the bottom of the grid.



**Figure 1.** Example of the grid.

The following is an example what should be shown in your display during the use. The text typed by the user is printed bold.

```

DIONYSOS> zgrid
Program generates a grid that can be used for
computing single jet flows.
There are two alternative ways to generate a grid:
1. Program calculates the size of the grid automatically.
2. Grid is calculated using given measures and number of control volumes.
Insert number of the alternative:
2
Insert the width of the nozzle(s) (mm):
2.875
Insert the number of the control volumes (4,8,16) in the nozzle:
16
Insert dimensions of the grid (mm):
Horizontal(X):
575
Vertical(Y):
250
Insert the number of the control volumes
Maximum number of control volumes is 128
and it should be able to divide it by 16.
X-direction:
128
Y-direction:
80
X-expansion ratio: 1.026118
Y-expansion ratio: 1.088348

```

### 3 How does it work?

Calculation of the grid dimensions is based on velocity distribution equations written as [1]

$$\begin{aligned}
 u &= \frac{\sqrt{3}}{2} \sqrt{\frac{K\sigma}{x}} (1 - \tanh^2 \eta) \\
 v &= \frac{\sqrt{3}}{4} \sqrt{\frac{K}{x\sigma}} [2\eta(1 - \tanh^2 \eta) - \tanh \eta]
 \end{aligned} \tag{1}$$

where  $K$  is kinematic momentum definition,  
 $\sigma$  is emprirical constant (7.67),  
 $x$  is distance from the nozzle and  $y$  from centerline and  
 $\eta = \sigma \frac{x}{y}$ .

In the  $x$ -direction the basic idea is to calculate the point where the centerline velocity has dropped below a wanted ratio (comparing it to nozzle velocity).

In  $y$ -direction the width of the grid is slightly bigger than the width of the jet at the end of the grid in  $x$ -direction.

The size of control volumes is increasing along the distance from the jet and centerline, respectively. The program computes the expansion rate so that in  $x$ -direction half of the volumes are used when the velocity has dropped to the half of its maximum value. In that way better computing accuracy is used where gradients are bigger.

In  $y$ -direction expansion rate depends on the size of the nozzle and on the number of control volumes within nozzle.

In both cases optimal expansion rates, i.e. that the last point of the grid is positioned in a wanted place, are computed using geometric sum and iterated with a bisection method. The bisection method is not the most efficient alternative but there is no benefit of using a more sophisticated method because the limit of calculation accuracy is achieved quite fast.

## References

- [1] Schlichting, H., *Boundary Layer Theory*. 7th ed. McGraw-Hill Book Co. New York, 1979. ISBN 0-07-055334-3.